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Population ageing, household portfolios and financial asset returns: A survey of the literature

by Marianna Brunetti

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CEFIN – Centro Studi di Banca e Finanza
Dipartimento di Economia Aziendale – Università di Modena e Reggio Emilia
Viale Jacopo Berengario 51, 41100 MODENA (Italy)
tel. 39-059.2056711 (Centralino) fax 059 205 6927

Population ageing, household portfolios and financial asset returns:

A survey of the literature

Marianna Brunetti

University of Modena and Reggio Emilia and CEFIN[*]

brunetti.marianna@unimore.it

Abstract

Population ageing is a recognised phenomenon affecting many countries in the world including most EU ones, Japan and US. The financial implications of this phenomenon can be manifold and some recent literature has focused in particular on the possible consequences of ageing on household portfolios and on main financial asset returns ones. Overall, the extant literature on household portfolios reports a significant effect of age on asset allocation, thereby providing evidence in favour of the standard life-cycle hypothesis. On the other hand, empirical results on the link between demographics and financial asset prices/returns are less uniform. The aim of this paper is to systematize the extant literature on these issues and to provide an overview of the main results reported so far, trying to evaluate whether the different conclusions reached depend on the approach taken in the empirical exercises rather than on the actual differences, in terms of demographic dynamics, public pension systems and financial markets, of the realities considered.

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List of abbreviations

AMH	Asset Meltdown Hypothesis
HRS	Health and Retirement Study
LCH	Life-Cycle Hypothesis
MI	Macroeconomic Indicators
MY	Ratio of middle-aged to young people
NW	Net Wealth
OLG	Overlapping-Generations models
PAYG	Pay-As-You-Go
SCF	Survey of Consumer Finance
SHIW	Survey of Household Income and Wealth
TIAA	Teachers Insurance and Annuity Association–College Retirement Equities Fund

1. Introduction

Population ageing is a recognised and worldwide phenomenon, although it affects some countries more than others, especially Japan and, among European countries, Italy.[1] Among the manifold potential implications of population aging (e.g. on living standards, labour market productivity and public finances), there are those concerning financial markets which stem from the fact that elderly generally have lower saving rates and higher average risk aversion. Population ageing might thus entail a progressive evolution of financial needs and preferences which may translate into in different portfolio allocations and hence affect financial assets prices and returns.

The lively debate ongoing on this issue has given rise to a vast literature of both theoretical and empirical contributions.

From a theoretical point of view, a valid starting point to formally study the link between demographics and financial markets is offered in Poterba (2001), who models this relationship in a simplified overlapping generation (OLG) framework. The individuals are supposed to live for two periods: when young they work and save a fixed rate (s), when old they retire and consume. Production is normalized to one and there is only one asset on the market which is fixed in supply (K). In equilibrium supply equals demand, i.e.:

$$p * K = s * N_y \qquad (1)$$

where N_y is the number of young and p the relative price of asset. In this framework, a rise in the number of young workers, due for example to a baby-boom, drives up asset prices as both supply and the saving rate are fixed. The Asset Meltdown Hypothesis (AMH) is based on the same rationale, since as Poterba (2001) puts it: "*a rise in the birth rate, followed by a decline, first raises then lowers asset prices*". The model by Poterba (2001) rests on simplifying hypotheses, such as an economy closed to international capital flows and both saving rate and capital supply fixed. The effect of the fixed-capital hypothesis is stressed by the same Poterba (2001), who writes that "*the effects are quite sensitive to whether or not capital is in variable supply. With a fixed supply of durable assets, asset prices in the baby boom economy rise to […] 35% above*

[1] Evidence of the exceptionality of world population ageing, and especially of the Italian one, can be found in many recent studies, such as Visco (2005) and Brunetti and Torricelli (2007a).

their level in the baseline case. This effect is attenuated, to a 15% increase […], in a production economy". Hence, once these simplifying hypotheses are relaxed the results might differ. For example, in Abel (2001) the model is extended by allowing a variable capital supply and including the bequest motive. The former change alone does not change the AMH conclusion, but when coupled with the bequest motive the conclusion reached is quite different as "*equilibrium dynamics of the price of capital are completely unaffected*". In a subsequent work – Abel (2003) – the model is completed with a social security system, which in the long run ends up by affecting national savings and investments but not the price of capital: the latter in fact, after an initial increase in response to a baby boom, follows a mean reverting behaviour. On the other hand, Geanakoplos et al. (2004) consider the role of expectations and prove that with myopic agents an increase in the size of middle-aged translates into a proportional increase in the stock prices, while with agents fully anticipating the demographic changes the increase can be even more than proportional. Even with further features of realism (e.g. business cycle shocks, uncertainty in wages and dividend), the final impact of demographics on stock prices is still there, although it varying in terms of magnitude. Finally, open-economy models allowing for international capital flows (e.g. Cutler et al., 1990) generally lead to less dramatic previsions, as the ageing process occurring at different paces across countries can compensate through (integrated) markets.

In sum, the existing theoretical literature proves that a relationship between demographic dynamics and financial markets is plausible, but still does not provide clear indications about the magnitude, the timing and in some cases even the direction of the eventual consequences of population ageing on financial markets. Based on this, several empirical studies have recently been performed, differing substantially not only for the implications investigated, the methodology taken and the countries analysed, but also for the results obtained. A brief review of this empirical literature could thus help in clarifying the main findings reported so far about the possible consequences that ageing might entail for financial markets in the years to come.

In particular, in this paper we will concentrate on the empirical studies concerning the impact that population ageing might have on household portfolios and on financial asset prices and returns.[2] Even if this overview is not meant to be exhaustive, the task is not an easy one since the literature on these issues is growing fast and is highly diversified. In some cases the works differ even for the demographic measure chosen to assess ageing itself: some use simple average or median age, some others opt for dependency ratios, i.e. the ratio of non-working to working population (whose definition might also differ across countries depending on the official age of entering and leaving the labour market). Furthermore, due to the relative infancy of this literature a unique and well-established approach for the empirical exercises is still lacking. Yet, the methodologies taken in most contributions, either on household portfolios or on financial asset returns, can be traced back to three main categories, hereafter referred to as follows: (i) "explorative", for the studies based on the analyses and interpretations of survey data; (ii) "econometric", for those employing time-series, cross-section or panel data regressions; and (iii) "simulation-based", for studies performing simulations on suitably structured models. An overall picture of the whole studies surveyed, sorted by both focus and main approach, is presented in Table 1.

The reminder of the paper is organized accordingly: Section 2 collects the studies concerning the impact of age on household portfolios and presents them into three different subsections according to the main approach used in the empirical exercise. The same holds for Section 3, which gathers those studies examining the impact of demographic changes on financial asset prices and/or returns. Last Section concludes.

[2] Studies such as Auerbach et al. (1989), Visco (2002), Bloom and Canning (2004), Onofri (2004), and more recently Oliveira et al. (2005), Gómez and Hernández (2006), Leigh (2006), Batini et al. (2006) and Bloom et al. (2006) and Sheiner et al. (2007) which study the consequences of demographic changes on the macroeconomic equilibrium are thus behind the scope of this survey. In fact, most of them however have already been surveyed, e.g. in Browining and Lusardi (1996), Kohl and O'Brian (1998) or Bosworth et al. (2004). Furthermore, the works considered here generally evaluate the possible impact of demographic changes on financial asset returns using as transmission mechanism the changes in individual or household financial portfolios. A different approach would be to examine how ageing might affect aggregate financial asset demand in retirement saving plans rather than in household portfolios (see among others, Shieber and Shoven (1997) and more recently Visco (2005) and Poterba et al., 2007). Since a recent review of these empirical papers has already been provided, e.g. by Stowe and England (2001), these works will not be considered in this paper. In addition, the effective quantification of ageing implications for stock or bond returns via changes in retirement asset accumulation is particularly complex due to a number of factors, above all the fact that in many countries retirement plans are still in their infancy.

Table 1: Empirical contributions reviewed by focus and approach.

Focus	Approach	Study	Country	Period	Technique	Main Results
Portfolio allocation	**Explorative**	Poterba and Samwick (1997)	US	1983, 1989, 1992	/	Confirm LCH
		Bodie and Crane (1997)	US	1996	/	Confirm LCH
		Ameriks and Zeldes (2004)	US	1987- 1999	/	Confirm LCH
		Brunetti and Torricelli (2007a)	Italy	1995-2005	/	Confirm LCH
	Econometric	Yoo (1994b)	US	1962, 1983, 1986	C+T	Confirm LCH
		Guiso et al. (2001)	Italy, Germany, Neth., UK, UK	1990s	C+P	Decision but not allocation
		Coile and Milligan (2006)	US	1992-2002	P	Confirm LCH
		Ganelli (2006)	Czech Republic	1992-2000	P	Relevant effect of age
		Bellante and Green (2004)	US	1993-1994	C	AMH overstated
	Simulation	Cerny, Miles and Schmidt (2005)	UK	1945-2110	O_{oe}	Confirm LCH
Asset Prices or Returns	**Explorative**	Arnott and Casscells (2003)	US	1940-2050	/	Ageing ↑ equity premium
		Schich (2004)	G7	1978-2000	/	Weak link
	Econometric	Poterba (2001)	US, Canada, UK	1983 -1995	P	Weak link
		Poterba (2004)	US	1926-2003	T	Weak link
		GAO (2006)	US	1948-2004	T	No risk of AMH
		Bakshi and Chen (1994)	US	1900-1990	T	Confirm LCH
		Yoo (1994a)	US	1926-1988	T	Significant effects
		Goyal (2004)	US	1926-1998	T	Significant effects
		Brunetti and Torricelli (2007b)	Italy	1958-2005	T	Significant effects
		Erb et al (1997)	18 OECD	1970-1995	T+C+P	Significant effects
		Davis and Li (2003)	7 OECD	1950 - 1999	P+T	Significant effects
		Ang and Maddaloni (2005)	G5, 15 countries	1900-2001,1970-2000	C+P	↓ expected excess returns
		Brooks (2006)	16 OECD countries	1900-2005	P	Significant on prices, not returns
	Simulation	Brooks (2000)	/	/	O_{ce}	Significant effects
		Brooks (2002)	US	1870-2020	O_{ce}	Significant effects
		Geanakoplos et al. (2004)	US, UK, Germany, France, Japan	1950-2001	O_{ce} + T	Mixed result
		Kedar-Levy (2006)	US	1950-2050	DAPM	Increase prices
		Young (2002)	UK	1926-2030	O_{oe}	Modest effect
		Borsh-supan et al (2003)	Germany	2000-2050	O_{oe}	Only temporary effect
		Oliveira Martins et al. (2005)	US, Japan, Germany, France	1970-2050	O_{ce}	AMH overstated
		Saarenheimo (2005)	USA, EU-15, Japan, China, India	2000-2050	O_{oe}	No risk of AMH

The table reports the studies reviewed, sorted by focus and main empirical approach. For each contribution, the table reports the countries and the data period considered, the main results as well as the technique used in the empirical analyses, where: O_{ce} = simulations on closed-economy OLG model, O_{oe} = simulations on open-economy OLG model, DAPM =simulations on dynamic asset-pricing-model, C= Cross-section regression, T = Time-series regression, P = Panel regression.

2. Population ageing and household portfolios

In this section we go through the main studies empirically investigating the possible impact of population ageing on household financial portfolio choices. The contributions are basically framed into the standard life-cycle hypothesis (LCH), stating that young generally invest a bigger share of their portfolios in riskier activities while older people, having a shorter time-horizon, tend to be more risk-adverse and choose safer assets to safely finance their retirement. Studies reviewed in Section 2.1 generally use an explorative approach, those in Section 2.2 make use of econometric techniques while empirical contributions based on model simulations are presented in Section 2.3.

2.1 Explorative studies

The works presented in this section generally investigate the age-wealth profile as from survey data, such as the US Survey of Consumer Finance (SCF). The data are used to compute either the probability of ownership of different assets and/or the average financial asset allocation of households across different age-classes.

Poterba and Samwick (1997) use data from the 1983, 1989 and 1992 waves of the SCF to test the life-cycle investment hypothesis and the risks-aversion life-cycle hypothesis. The former assumes that different ages imply different wealth allocations: in other words, population ageing will entail a lower (higher) aggregate demand for housing (financial assets) and hence ceteris paribus, a depression (rise) in housing (financial asset) prices. The risk-aversion hypothesis, on the other hand, states that relative risk-aversion increases with age, implying therefore a progressive increase in the equity risk premium as a consequence of ageing. Survey data analyses provide evidence in favour of both hypotheses. As for the former, both the probability of ownership and the average share allocated in housing, financial assets and liabilities show that investments in real estate display a hump-shaped pattern while those in financial assets follow exactly the opposite trend. Besides, focussing on the average shares invested in six main financial-asset categories, including equities, bonds and bank accounts, Poterba and Samwick (1997) observe that each category behaves differently over the life-cycle: on average, the shares invested in bonds tend to increase with age, those held in bank accounts tend to decease while the shares invested in equities follow an humped-shaped pattern. Based on this evidence, the authors conclude that age significantly affects both the probability of ownership and the final portfolio allocation.

A similar analysis is performed by Bodie and Crane (1997), who examine the average household allocation into three broad financial-asset classes, i.e. cash, fixed-income securities and equities. Differing from Poterba and Samwick (1997), data are taken from the 1996 Teachers Insurance and Annuity Association–College Retirement Equities Fund (TIAA-CREF), the analysis is performed at an individual rather than at a household level and individuals are grouped by age-classes and Net Wealth (NW) quartiles. Yet, the results reported, confirmed also by an econometric dummy regression, are in line with Poterba and Samwick (1997) and with generally accepted investment principles: the shares invested in equities tend to reduce with age.

Ameriks and Zeldes (2004) use both data sources: i.e. the 1989, 1992, 1995, and 1998 SCF, and the 1987-1999 TIAA-CREF. On both datasets the authors perform first explorative and then regression analyses. As for the former, the authors provide graphical representations of the dataset in both cross-section and cohort view: in the cross-section representation, all observations referring to the same year are connected together and plotted against population age classes, while in the cohort-view observations of the same birth cohort are connected together and plotted against age classes. Cross-section representations highlight the hump-shaped pattern of the portfolio shares held in equities: the share invested in stock raises along with age until investors are in their late forties, stabilizes until they are in their late fifties and then declines as they reach retirement age. On the other hand, cohort views suggest that the average equity exposure has constantly increased with age for nearly all cohorts. As for the econometric exercise, the authors estimate two dummy-variable regressions: the equity share of portfolio is regressed first on age and time dummies and then on age and cohort dummies. In both cases, the age coefficient is significant and implies that the fraction of portfolio invested in equities reduces as investors age, passing from the 60% of middle-aged to less than one half of people about to retire. Hence, both explorative and econometric analyses confirm the relevant effect of age on portfolio allocation.

Evidence on the LCH however is not limited to the US case. In a recent study, Brunetti and Torricelli (2007a) examine the Italian household portfolios using data taken from the Bank of Italy Survey of Household Income and Wealth (SHIW) and spanning over the period 1995 – 2004. The authors first group financial assets into comparable credit and market risk-categories and then examine the average portfolio by dividing households first by age-classes, in order to depict a possible age-effect on allocation choices, and then by both age-classes and NW quartiles, in order to test whether the age-effect persist even under different economic conditions. In addition, the 5% richest households are separately studied. Results show that, despite the several changes occurred over the decade 1995-2004, the average Italian household portfolios are allocated consistently with the life-cycle theory: middle-aged hold riskier portfolios, while older ones tend to disinvest risky financial instruments and turn to safer assets. As the age-effect is depicted also across all NW quartiles, with the sole exception of 5% richest households, the authors conclude that the age-effect on financial choices is overall robust to both economic conditions and to the market changes occurred during the decade under analysis.

2.2 Econometric studies

The empirical studies estimating the average portfolio allocation as function of age face an important identification problem, which stems from the fact that financial choices are simultaneously affected by three different but related effects, namely age, time and cohort effect. Time effect refers to the particular moment in which the survey is taken. As an example, a favourable (negative) period for stock market returns not only increases (decreases) the average financial wealth of households, but may also modify its average allocation at all ages. The cohort effect concerns those consequences that the date of birth may have on individual financial choices. As Poterba (2001) puts it: "*individuals born prior to the Great Depression may have a greater desire to save than those born later, reflecting their greater experience with economic hardship and the loss of financial wealth*". Finally, the age effect captures the life-cycle effect on financial wealth allocation. Empirically speaking, the identification problem can be summarized as follows: at any time *t* a person born in year *c* is a_t years old, where $a_t = t - c$. Being age (a_t), time (*t*) and cohort effect (*c*) a linear combination of each other, they can not be separately identified. The solution is to rule out one of them and try to assess the two remaining. Yet, time-series or single cross-section data allows depicting only one of them at time: that is why most of the studies presented in this section use panel data or repeated cross-sections, which instead allow the separate estimation of two out of three of these effects.

Two observations are here in order. First, the empirical contributions presented in this subsection make use of panel data in which the observations repeated over time refer to different households (while in Section 3.2. the additional dimension besides time is due to the pooling of observations referred to different countries). Second, the methodology usually taken consists in running regressions where the dependent variable is either a binary variable for asset owning or the share of financial portfolio held by each household in some financial assets and the explorative ones represent various factors that generally affect household allocation choices.

Yoo (1994b) uses data from 1962 Survey of the Financial Characteristics of Consumers and the 1983 and 1986 SCF. After a preliminary explorative analysis, which suggests life-cycle-consistent portfolio allocation, the author estimates the following cross-sectional regression[3]:

$$\begin{aligned}\alpha_i = \beta_0 + \beta_1 Pop_i^{25-34} + \beta_2 Pop_i^{35-44} + \beta_3 Pop_i^{45-54} + \beta_4 Pop_i^{55-64} + \beta_5 Pop_i^{65+} + \beta_6 \#Kid_i + \beta_7 \#Adult_i \\ + \beta_8 Male_i + \beta_9 White_i + \beta_{10} Married_i + \beta_{11} HS_i + \beta_{12} Col_i + \beta_{13} Y_i + \beta_{14} W_i + \varepsilon_i\end{aligned} \quad (2)$$

where α_i is the portfolio share held in different financial assets (cash, bonds and equities) and ε_i represents the error term.[4] Explanatory variables include dummies for age-class ($Pop_i^{25-34},..., Pop_i^{65+}$), gender (*Male*), marriage status (*Married*), High School (*HS*) and College (*Col*) education, as well as the number of children *(#Kids*) and adults (*#Adult*) in the household, the income (*Y*) and the wealth (*W*). Results suggest that age is a significant factor in determining portfolio composition and that, consistently with the life-cycle model, the share held in equities increases while working and decrease after retirement.

In the light of the manifold changes occurred to financial markets during the 1990s, Guiso et al. (2001) present a number of relevant papers referred to several countries, namely Alessie et al. (2001) for the Netherlands, Banks and Tanner (2001) for UK, Bertaut and Starr-McCluer (2001) for US, Eymann and Börsch-Supan (2001)

[3] The author also estimates a time-series regression using data spanning over the period 1945-1990 and obtains consistent results.
[4] In all regression models presented hereafter, the symbol ε will denote the error term.

for Germany and Guiso and Jappelli (2001) for the Italian case. All empirical studies basically follow the same methodology. First, financial assets are grouped into three broad risk-categories: “safe” (e.g. bank accounts), “fairly safe” (e.g. T-Bills and similar) and “risky” (e.g. stocks), whereby the definitions may slightly change from country to country. Furthermore, the “participation” decision, i.e. whether or not to hold risky assets, is distinguished from the “allocation” decision, conditional on the former and referring to the share of total financial wealth to invest in that assets. Then, both explorative and econometric analyses are performed. As for the former, the authors basically examine the average household portfolios across different age-classes. Except for the Dutch and the German cases, a clear humped-shaped age-profile is observed, at least with regards to the participation decision. For instance, for the US case Bertaut and Starr-McCluer (2001) report that the average share invested in risky assets peaks for households aged between 45 and 64 while declines moving towards younger or older investors. Similarly, Guiso and Jappelli (2001) observe that the share of Italian households investing in risky assets increases from around 15% of the aged less than 30 to almost 20% of the middle-aged and then falls once again to around 10% for the 60-69 and to less than 7% for the over 70. By contrast, Eymann and Börsch-Supan (2001) for Germany and Alessie et al. (2001) for the Netherlands report that elderly seem more willing to hold risky assets. Finally, the authors turn to econometric analyses. In particular, national survey data are used to estimate either cross-sectional and/or panel regressions in which the dependent variable is either a binary variable for the participation decision and/or the share of financial wealth invested in some assets for the allocation decision. Explicative variables include all other household features which could play a role in determining the participation or the allocation decisions, including age, net wealth, income, gender and level of education. Clearly the exact specification varies across countries. For instance, Guiso and Jappelli (2001) for the Italian case estimate (with both cross-section and panel data):

$$\alpha = \beta_0 + \beta_1 A + \beta_2 \frac{A^2}{1000} + \beta_3 Y + \beta_4 \frac{Y^2}{1000} + \beta_5 W + \beta_6 \frac{W^2}{1000} + \beta_7 Size + \beta_8 Kids + \beta_9 Married + \beta_{10} Male + \beta_{11} South + \beta_{12} Edu + \beta_{13} u + \beta_{14} Bank + T + \varepsilon \tag{3}$$

where the dependent variable is in turn the dummy variable or the share invested in risky assets and explanatory variables include the age of the family head (*A*), both in linear and quadratic terms, household income (*Y*) and wealth (*W*), the family size (*Size*) and the number of children (*Kids*), dummy variables for the marital status (*Married*), the gender (*Male*), geographic zone of residence (*South*) and the level of education of the family head (*Edu*), as well as the average unemployment rate (*u*) and the index of bank diffusion (*Bank*) in the province of residence together with year dummies (*T*). On the other hand, Bertaut and Starr-McCluer (2001) for the US case estimate:

$$\alpha_i = \beta_0 + \beta_1 A_i^{<35} + \beta_2 A_i^{55-64} + \beta_3 A_i^{65+} + \beta_4 \ln(Y_i) + \beta_5 \ln(W_i) + \beta_6 NonWhite_i + \beta_7 HS_i + \beta_8 Col_i + \beta_9 Married_i + \beta_{10} Female_i + \beta_{11} Self_i + \beta_{12} DBPens_i + \beta_{13} RET_i + \beta_{14} u_i + T + \varepsilon \quad (4)$$

where the dependent variable is again either a dummy for the participation decision and the share invested in risky assets for the allocation one. On the other hand, explanatory variables include dummies variables for age-class ($A_i^{<35}, A_i^{55-64}, A_i^{65+}$), log income ($\ln(Y)$) and wealth ($\ln(W)$), and dummies for being non-white (*NonWhite*), for the highest level of education (*HS* for High School and *Col* for College), for the marital status and the gender (*Married* and *Female*), for being self-employed (*Self*), retired (*RET*) or owner of a defined-benefit pension fund (*DBPens*), as well as the average unemployment rate (u) in the state of residence. In all studies but the Dutch, the results confirm that age plays a significant role in determining whether or not to hold risky assets, although once this decision is taken these factors only slightly affect the final portfolio allocation. For instance Guiso and Jappelli (2001) in a probit regression for participation report that age coefficients are statistically different from zero and quite high in magnitude (probability of holing risky assets increasing by 4% between age 25 and 40 and declining by 8% between age 40 and 70) while in the portfolio-allocation regression they are still significant but sensibly smaller in magnitude. Similarly, Banks and Tanner (2001) for UK report that the probability of holding risky-asset progressively increases with age-classes up to 60-69 age-class and then falls.

The analysis by Coile and Milligan (2006) to some extent completes the investigation of US household average portfolios since it specifically focuses on its evolution after retirement. Five asset categories are considered: (i) principal residence; (ii) vehicles; (iii) financial risky assets, including bonds, Individual Retirement Accounts (IRAs) and stocks; (iv) bank accounts; and (v) business and other real estate. To this end, the authors use six waves of the US Health and Retirement Study (HRS) spanning over the period 1992-2002 and estimate by means of OLS the following panel regression:

$$\alpha_{it} = \beta_0 + \beta_1 Age_{it} + \boldsymbol{\beta}\mathbf{X}_{it} + \gamma_t + \varepsilon_{it} \quad (5)$$

where the dependent variable is either a dummy for the household holding the asset class, the share of total assets held in each asset-class or the dollar amount held in each asset-category. Explanatory variables include the wave dummies (γ_t), the age of the older member of the household (Age_{it}) and a set of control variables ($\mathbf{X}_{it}$), including marital status, region of residence, religion, race, being US born, and educational category. The age-coefficients are overall significant and negatively signed for all assets but bank accounts: i.e. older households have generally lower ownership probability and hold lower shares/dollar amounts of all assets but bank accounts. Coile and Milligan (2006) note that "*bank accounts are dominated by other assets on a risk-return basis, yet there is an increasing proportion of household assets devoted to them with age. […] It may be a transitory result as windfalls of insurance money, pension lump sums, or proceeds from the sales of housing pass through bank accounts on their way to other asset classes. Alternatively, it may be that the complexity of financial arrangements leads seniors, particularly those with diminished mental or physical capacity, to select portfolios that are easier to manage.*" Based on this evidence, the authors conclude in favour of sizeable effects of age on asset allocation over the long-term.

To date, the empirical literature on ageing and household portfolios has given only scant attention to emerging economies. An exception is represented by Ganelli (2006) who focuses on household financial portfolios in Czech Republic. The latter is in fact an interesting case-study both because recent financial market and pension systems changes have shifted both market and longevity risks to the household sector and because the projected Czech old-age dependency ratio is likely to be among the highest in Europe[5]. Ganelli (2006) first discusses recent financial trends in Czech household wealth in a comparative perspective with G-7 countries. The author uses G-7 data spanning over the 1992-2000 period to derive the structural determinants, and hence the benchmark levels, of assets and liabilities that Czech household should have in order to better react to ageing. The author thus runs the following panel regression:

[5] On this issue see, among others, Fernández-Ansola et al. (2005) and Brunetti and Torricelli (2007a) and references therein.

$$\left(\frac{FA}{Y}\right)_{it} = \beta_0 + \beta_1 gdp_{it} + \beta_2 MC_{it} + \beta_3 \pi_{it} + \beta_4 AGESpending_{it} + \beta_5 ODR_{it} + \varepsilon_{it} \qquad (6)$$

where the dependent variable is the ratio of financial assets to household disposable income and explanatory variables include: inflation (π_{it}) and per-capita GDP (gdp_{it}) as proxies of macroeconomic conditions, the ratio of market capitalization of listed companies to GDP (MC_{it}) as proxy for financial market development, the ratio of old-age-related public expenditure to GDP ($AGESpending_{it}$) as proxy of public pension-system generosity and the old-age dependency ratio (ODR_{it}) as proxy of the ageing process. Consistently with expectations, the author finds positive signs for β_1 and β_2 while negative ones for β_3 and β_4. As for β_5 the possible result is ambiguous: if on one hand the standard life-cycle theory suggests a negative sign, on the other younger could anticipate that ageing is threatening public pension systems sustainability and hence increase their precautionary savings, thereby raising $(FA/Y)_{it}$. The resulting coefficient is significant and positively signed leading to the conclusion that the latter effect seems to prevail. Ganelli (2006) argues that not only the amount but also the composition of household portfolios should be modified in response to ageing: by a comparative inspection with Netherlands, Germany and US it emerges that Czech households hold portfolios excessively unbalanced, concentrating almost 80% of their total wealth in non-financial and in low-return financial assets, "*probably not adequate to permit them to save for retirement*". The lack of long-term saving instruments is quoted among the possible causes of the current unsatisfactory portfolio composition.

All empirical works presented so far report a significant effect of age on household financial portfolio and, based on this evidence, claim the plausibility of the AMH. By contrast, Bellante and Green (2004), who also find age to be a significant determinant of portfolio allocation, do not support this argument. In their contribution, the authors test the life-cycle risk-aversion hypothesis specifically for elderly. Using a single cross-section dataset on a subset of US households whose one or more members are 70 or over in 1993-1994, the authors estimate several regressions by means of OLS, among which:

$$\alpha_i = \beta_0 + \beta_1 \ln(NW)_i + \beta_2 \left[\ln(NW)\right]_i^2 + \beta_3 Age_i \ln(W)_i + \beta_4 Female_i + \beta_5 Male_i + \\ + \beta_6 Health_i + \beta_7 Non-White_i + \beta_8 HS_i + \beta_9 College_i + \beta_{10} Kids_i + \varepsilon_i \quad (7)$$

where α_i is the share of risky assets in the financial portfolio of *i*-th household, $\ln(NW)$ the log of net wealth, *Age* the age of the head-of-the-household minus 65, *Kids* the number of children and *Female*, *Male*, *Health*, *Non-White*, *HS* and *College* are dummies respectively for gender, health status, race and highest education level. Overall, all coefficients but β_5 and β_{10} are significant and display the expected sings. In particular, the age-coefficient is negatively signed and highly significant, suggesting that the share held in risky assets tends to reduce with age, i.e. that ageing is typically associated with a stronger relative risk-aversion. Nevertheless, the authors conclude that "*the concern for a securities market ''meltdown'' may be grossly exaggerated, since as retirees age, they do not seem greatly inclined to sell off their risky assets. […] Moreover, when the baby boomers and later generations retire, they will be substantially more educated than those sampled in the present study. Given our finding of a greater tendency of the more educated to invest in risky securities in old age, there is one more reason to suspect that concerns for a dramatic shift in the market returns to risky assets may be unwarranted.*"

2.3 Simulation-based studies

In order to estimate the possible impact of ageing on portfolio allocation by means of model simulations the basics steps generally taken are: (i) to structure the model, typically based on a portfolio optimization problem in which the final allocation is affected by an age-dependent parameter; (ii) to calibrate the model, either assuming certain values for the relevant parameters or using data referred to one or more countries to find a steady-state solution which reflects the current equilibrium; and finally (iii) to perform simulations generally under different scenarios of demographic changes, agent behaviour and/or public pension-systems. As far as known, this approach is not the most widespread when the aim is the empirical investigation of the sole age-profile of household portfolios: probably, complexity and computational costs associated with these models make them more suitable for simulating the ageing consequences on the whole macroeconomic equilibrium rather than on the sole portfolio allocation.

Given the limited literature on the issue only one paper is presented in this section, namely Cerny et al. (2005). The authors structure an OLG model in which rational and forward-looking households optimize the allocation between risky and safe financial assets and housing. After having calibrated the model on the UK economy, the authors perform simulations under three different scenarios: (i) base, with retirement age at 62 and replacement ratio at 30%; (ii) replacement rate reduced to 19%; and (iii) retirement age increased to 70. Under all scenarios, the optimal portfolio composition substantially varies with age: portfolios of older households generally show decreasing portion of real assets and increasing importance of financial ones, whereby within the latter safe assets tend to progressively increase with respect to risky ones along with the age of the household.

3. Ageing and financial asset prices and returns

This section goes through the main empirical literature focussed on the link between demographic dynamics and financial asset prices and returns. Provided that LCH holds, which is what many studies reviewed in the previous Section suggest, a wider share of young population increases the aggregate demand for risky assets thereby exerting upward pressure on their prices and returns. By contrast, the preference of elderly for liquid and safe portfolio allocations is likely to increase the demand for fixed-income assets, such as government bonds, increasing their prices and ultimately reducing their returns (given the inverse relation linking bond prices and returns). Hence, substantial changes in the demographic age-structure of the population, such as the one entailed by the progressive population "greying", might relevantly affect financial assets prices and returns. As in the previous Section, the studies are sorted according to the main approach used in the empirical exercises: Section 3.1 for explorative studies, Section 3.2 for the econometric ones and Section 3.3 for those simulation-based.

3.1 Explorative studies

The works taking an explorative approach to study the demographic-financial link generally compare financial and demographic measures over time, trying to seek a common trend. The relative straightforwardness of the approach is however counterbalanced by the impossibility of providing some assessment of the strength and significance of the link.

According to Arnott and Casscells (2003): "*The simple mechanisms of supply and demand should lower the return on assets: a larger group of retirees than ever before will be selling to a proportionately smaller working population than ever before*". Furthermore, the authors claim that ageing is likely to increase the equity risk premiums. Using data referred to US and spanning over the period 1940-2050 Arnott and Casscells (2003) find evidence consistent with their expectations and forecast the first effects to manifest only around 2015. Yet, the need for action on capital markets is urgent and the authors suggest financial, macroeconomic and demographic measures. However, both financial (e.g. saving and investment rates increase, higher social security taxes) and macroeconomic measures (e.g. improvements of productivity and Third World trade, work force reallocation) may be either not resolving or even detrimental. The ultimate solution has thus to be demographic: either by encouraging immigration (emigration) of workers (retirees) and raising retirement age, whereby the latter is actually the most likely to be implemented. In particular, the authors estimate that, in order to offset the implications of ageing on financial markets, retirement age increase needs to increase to around 72 or 73 by the end of 2030.

Schich (2004) examines the correlation between weight of different age-cohorts and annual average real equity returns in G7 countries, namely US (over the period 1957 – 2000), Japan, Canada, France, Germany, Italy and UK (over the period 1978-2000). In all countries, correlation coefficients are significant at the 5%-level thereby providing some support for the demographic-financial link. The author then considers two important demographic moments: the end of 1980s, when "baby boomers" entered middle-age, and 2010, when they are expected to retire. Based on the evidence reported, in the first moment savings and financial assets are expected to increase, thereby putting upward pressure on asset prices, whilst the opposite is likely occur around 2010. However, no quantitative estimate is provided, since "*while demographic projections are generally quite accurate, some of the other trends related to saving, such as the growth of saving and asset choices may be influenced by yet unknown future policy measures*".

3.2 Econometric studies

This section is devoted to the empirical contributions which assess the link between demographic and financial prices and returns by means of econometric techniques. The basic methodology consists in regressing various measures of financial asset prices or returns on a set of explanatory variables including some demographic measures. Yet, the studies are highly diversified in terms of both regression specification and results obtained. Regression specifications, for instance, vary in order to better adapt to country characteristics and data availability. Not only, authors also choose different specifications in terms of: dependent variable, some times asset prices or returns, some others equity risk premium; explanatory variables, some times including both demographic and financial measures, some others exclusively demographic ones; and even for the demographic measures chosen, some times the average age of working population or old-dependency ratios, some others the proportion of different age-classes over the total population.

Most of the studies base their analyses on time-series data, facing however the problem of estimating a regression in which the (financial) dependent variable is highly volatile while demographic explanatory ones are slow-moving. The solution generally chosen is to increase the statistical power of the analyses by using either longer time-series, which however are not always available, or panel dataset, which pool observations from different countries (differing from works in Section 2.2. in which observations repeated over time refer to different households). Accordingly, in what follows we will first present works using time-series regressions and then those exploiting panel data.

The works by Poterba (2001, 2004) are considered seminal in the empirical investigation of population aging on financial assets prices and returns. The author tests the implications of his simplified OLG model (see Introduction) in different ways. For instance, by examining the age-profile of corporate stock holdings, net financial assets and net-worth for individuals in different age-classes, as from the 1995 SCF. It emerges that the asset holdings reach their apogee in the age-classes between 30 and 60 and then slightly decrease, although "*there is only a limited downturn in average asset holdings at older ages*". Next, the analysis is moved from single cross-section to repeated cross-section data (1983, 1986, 1989, 1992 and 1995 SCF) to estimate the following regression:

$$y_{it} = \sum_{j=1}^{13} \alpha_j Age_{ijt} + \sum_{c=1}^{12} \gamma_c Cohort_{ijt} + \varepsilon_{it} \qquad (8)$$

where the dependent variable is the level of either common stocks, net financial assets or net worth held by investor *i* at time *t*, Age_{ijt} is a dummy for *j* different 5-year age-groups (from 15-19 to 75 and over) and $Cohort_{ijt}$ is a specific intercept term for 5-year of birth-cohort (from 1971-1975 to before 1925). In this way the author focuses on age and cohort effects and implicitly assumes no time-effect. For the α_j coefficients Poterba (2001) reports that "*has a surprisingly small impact on the estimated age structure of asset holdings*". In fact, the values for late middle-aged and retired are not that different: around 32,500$ for the former against around 28,000 - 25,000$ for the latter. Furthermore, for net financial assets "*there is virtually no decline in old age"*, so that "*the rush to sell financial assets that underlies most predictions of "market meltdown" in 2020 or 2030 may be somewhat muted*". These age-wealth profiles are then merged with the projected evolution of US population over the period 2000-2050 to forecast the future aggregate asset demand of financial assets, i.e.:

$$PAD_t = \sum \alpha_j N_{jt} \qquad (9)$$

where PAD_t is Projected Asset Demand at time *t* for either common stock, net financial assets and net worth, α_j are the coefficients estimated in equation (8) and N_{jt} is the number of individuals belonging to age-class *j* in year *t*. Poterba (2001) reports that "*the aging of the baby boom cohort does not result in a significant decline in asset demand*", thereby disproving the asset meltdown hypothesis. Poterba (2001) also examines the historical relationship between population age-structure and asset prices and returns, by means of regressions like:

$$r_t = \beta_0 + \beta_1 Demo_t + \varepsilon_t \qquad (10)$$

where the dependent variable is the real return on either T-Bills, long-term Government Bonds or Stocks and $Demo_t$ represents several demographic measures, namely median age, average age of adult population (i.e. aged 20 or over) and the ratios of aged between 40 and 64 over total, adult and retired (i.e. aged 65 or over). The regressions are estimated using data for three countries and spanning over different time periods: US (full sample, 1926-1999, and post-war period, 1947-1999), Canada (1961-1997 for stocks and 1950–1997 for fixed-income instruments) and United Kingdom (1961–1996 for equities and 1950–1996 for fixed-income assets). As for US, the author reports only "*limited support for a link between asset returns and demographic structure*", whereby the best results are obtained for fixed-income markets and using the ratio of aged 40-64 over the total population as demographic measure. The estimated coefficients suggest that "*an increase in the fraction of the population in the key asset-accumulating years […] lowers observed returns*", although with implausibly large effects, so that omitted-variable problems are insinuated. As for Canada, the coefficients are statistically significant only for fixed-income assets and point towards a positive relation between real returns and middle-aged. By contrast, results for UK show negatively signed and generally non-significant coefficients, which "*further weaken the claim that demographic structure and asset returns exhibit systematic linkages*". Limitedly to US, Poterba (2001) also studies the relationship between demographic variables (*Demo*) and stock prices normalized by corporate dividend (*P/D*), by estimating the following regression both in levels and in first differences:

$$\left(\frac{P}{D}\right)_t = \beta_0 + \beta_1 Demo_t + \varepsilon_t \qquad (11)$$

When levels are used several demographic variables are significant, although the possibility of "spurious regression" can not be excluded. On the other hand, using first differences the coefficients are statistically significant in only two out of five cases. Finally, the projected asset demand (*PAD*) for common stocks, net financial assets and net, estimated with equation (9) are used to assess the impact on asset prices and returns by means of:

$$y_t = \beta_0 + \beta_1 PAD_t + \varepsilon_t \qquad (12)$$

where the dependent variable is either the real return or the price dividend ratio. Results for real returns suggest very limited linkage with PAD_t, especially over the whole sample. On the other hand, a positive relationship is found between PAD_t and the price-dividend ratio. Yet, the results appear quite sensitive to the choice of the sample period, thereby casting serious doubts about the robustness of the evidence found. In a following work, Poterba (2004) presents new findings on the historical correlation between population age structure and asset prices and returns, by estimating different specifications of (10) using US data spanning over the period 1926-2003. As in the previous study, the results are provided both over the whole sample period and over the post-war period (i.e. 1947- 2003), but the demographic measures considered are: (i) the share of the total population between ages 40 and 64; (ii) the share of the total population over age 65; (iii) the share of the adult population between the ages of 40 and 64; and (iv) the share of the adult population over the age of 65. Most of the estimated coefficients turn out to be non-significant, providing evidence against the relationship between asset returns and population age structure, at least over the last seventy-year period. However, results are slightly different when asset prices rather than asset returns are used as dependent variable, i.e. when the estimated model is:

$$\left(\frac{P}{D}\right)_t = \beta_0 + \beta_1 Demo_t + \boldsymbol{\beta}\mathbf{Z}_t + \varepsilon_t \qquad (13)$$

where Z_t represents a set of additional variables included as control variables, i.e. the real interest rate and the economic growth rates. The coefficients of demographic variables are generally found significant and correctly signed, but when the same regression is run in first differences the coefficients become non-significant again. This casts serious doubts on the robustness of previous results, despite Poterba (2004) recognises that they could also be ascribed to the simplifying hypotheses of the OLG model, i.e. closed-economy, fixed saving rates and capital supply and all the other economic effects of ageing neglected.

In GAO (2006) the possible impact of ageing on financial market prices is examined by means of a twofold analysis. First, the plausibility of dramatic dis-savings by retirees is checked, by means of SCF (HRS) data spanning over the period 1992-2004 (1994-2004). Then the historical link between financial and demographic dynamics is studied by means of econometric techniques. *Inter alia*, the explorative analyses show that many retirees continue to buy stocks in retirement and that whenever they liquidate assets, they do it only gradually since they are driven by both the bequest motive and the need to hedge longevity risk (only rarely faced with private annuities). Furthermore, almost two thirds of the baby-boomers' financial assets are concentrated in the portfolios of the 10% richest households, which are traditionally less sensitive to age-affect on asset allocations. Based on this evidence the authors argue that the AMH is not likely to realize. Turning to the econometric analysis, the authors estimate:

$$r_t = \beta_0 + \beta_1 DY_{t-1} + \beta_2 TS_{t-1} + \beta_3 DefSpread_t + \beta_4 \Delta IP_{t+1} + \beta_5 Demo_t + \varepsilon_t \quad (14)$$

where r_t is the real annual return on stocks while explanatory variables include: the dividend yield (DY_{t-1}), the term spread (TS_{t-1}), the default spread shock ($DefSpread_t$), the change in industrial production (IP_{t+1}) and a demographic variable ($Demo_t$) defined either as the proportion of the population age 40-64 or as the "middle-aged-to-young" or "MY" ratio, i.e. the ratio of aged 40-49 to those aged 20-29. The demographic coefficients are overall positively signed and statistically significant: yet, non-demographic variables can explain more variation in historical stock returns with respect to demographic ones, leading the authors to conclude that baby boomers' retirement is unlikely to have a dramatic impact on financial asset prices.

The works presented above are the only time-series studies providing only weak evidence of a link between financial and demographic dynamics. The evidence found in the relevant literature is generally quite different. Already since the work by Bakshi and Chen (1994), who use data spanning over the period 1900-1990 and choose as demographic variable the average age of the population aged more than 20. The rationale is twofold: first, people younger than 20 generally do not play a determinant role in economic decision making; second, the average age correctly measures ageing since as the authors note: "*the fraction of persons 65 and older can increase, but this does not necessarily mean that population is ageing, because the fraction of young persons may increase at the same time*". Bakshi and Chen (1994) first observe the co-evolution of the demographic variable with two financial measures, i.e. stocks and housing markets prices in four sub-periods of the last century: 1900-1945, in which average age constantly increased, 1946-1966, in which average age increased even more sharply, 1967-1980, in which average age slowed down, and 1981-1990, in which average age exploded. The authors find that in the two sub-periods of peaking average age the stock prices increased whilst those of housing market declined and vice versa. In effect, in a cross-correlation analysis the authors find that percentage change in average age is strongly and positively correlated to stock prices whilst negatively correlated to housing ones. The authors then turn to a time-series analysis to estimate the following Euler Equation:

$$E\left[e^{-k}\,\frac{C_{t+1}\,\exp\left[-\left(\gamma+\lambda\overline{A}_{t}^{20*}\right)\right]}{C_{t}\,\exp\left[-\left(\gamma+\lambda\overline{A}_{t}^{20*}\right)\right]}-(1-R_{t})-1\,|\,\mathbf{Z}_{t}\right]=0 \qquad (15)$$

which stems from the first order condition solving a standard optimization problem in which the agent maximises his utility function dependent on consumption (C_t),risk-attitude (measured by means of γ and λ)[6], demographic variable ($\overline{A}_t^{20+}$), as well as on real return on stocks (R_t) and the information available at time *t* (proxied with the set of instrument variables $\mathbf{Z}_t$). The GMM estimates of γ and λ are overall significant and, consistently with risk-aversion hypothesis, positively signed, with magnitudes ranging between less than 1 and 72, depending on the time period considered and on set of instrument variables used. Based on this, the authors also perform a forecasting exercise aimed to assess whether and to what extent demographic variables might predict future risk premiums (RP_{t+1}), i.e.:

$$RP_{t+1}=\beta_0+\beta_1\Delta\overline{A}_t^{20+}+\beta_2\Delta C_t+\beta_3 DivY_t+\beta_4 Term_t+\varepsilon_{t+1} \qquad (16)$$

where explanatory variables include the percentage change in average age and in real per capita consumption, as well as the dividend yield on S&P500 and the term premium. Several specifications of (16) are estimated by means of OLS over the whole sample as well as over different sub-periods. While results for the whole sample and the pre-war period are not fully satisfactory, over the post-war period β_1 is found significant, positively signed and quite high in magnitudes, leading the author to the conclusion that a progressively older population might substantially affect capital markets and, more specifically, increase the equity risk-premium.

Yoo (1994a) uses a multi-period OLG asset-pricing model to formally describe the relationship between age distribution and asset returns and empirically tests the model implications by means of both model simulations and econometric regressions, data taken from the US Survey of Financial Characteristics of Consumers and the SCF and spanning over the period 1926-1988. The simulations suggest that a 1% increase in

[6] In particular, the relative risk-aversion of an investor aged *x* is $\gamma+\lambda x$.

the relative size of the 45-year-old group can reduce the asset returns up to around 2%. The robustness of the result is tested by estimating the following regression:

$$r_t = \beta_0 + \beta_1 Pop_t^{25-34} + \beta_2 Pop_t^{35-44} + \beta_3 Pop_t^{45-54} + \beta_4 Pop_t^{55-64} + \beta_5 Pop_t^{65+} + \varepsilon_t \quad (17)$$

where r_t represents the real annual returns of six different types of US securities (common stocks, small company stocks, long-term corporate bonds, long-term government bonds, intermediate-term government bonds, T-Bills) and the explanatory ones represent the fractions of population in different age-classes. Yoo (1994a) reports that β_1 has negative sign for stock returns whilst positive for bond returns, confirming that a higher incidence of young population is typically associated with higher (smaller) demand for risky (safe) assets. Since β_1 is not always significant the author concludes that the relationship between young population and asset returns might not be that strong. On the other hand, β_3 is strongly significant and negatively signed in all cases considered meaning that a huger middle-aged class increases the demand for all kinds of assets, thereby reducing the associated returns. Finally, β_4 displays different signs depending on the asset: positive for stocks whilst negative for bonds, confirming that people about to retire disinvest risky assets and prefer long-term risk-free bonds. As both econometric and OLG simulations provide consistent empirical evidence, the author concludes that demographics take part in the determination of the financial assets returns.

As Yoo (1994) and Poterba (2001, 2004), Goyal (2004) studies the link between age-structure and stock market returns in an OLG framework and empirically test its implications by means of econometric techniques. In fact, US data spanning over almost all twentieth century are used to estimate, both in levels and in first differences:

$$RP_{t+1} = \beta_0 + \beta_1 \overline{A}_t^{25+} + \beta_2 Pop_t^{25-44} + \beta_3 Pop_t^{45-64} + \beta_4 Pop_t^{65+} + \beta_5 DY_t + \beta_6 Flows_t + \varepsilon_t \quad (18)$$

where RP_{t+1} is the next-year excess stock returns and explanatory variables include several current demographic variables, namely the average age of the population above 25 ($\overline{A}^{25+}$) and the proportions of people aged between 25-44, 45-64, and 65+ ($Pop_t^{25-44}, Pop_t^{45-64}$ and Pop_t^{65+}), as well as two control variables, i.e. the dividend yield (DY_t) and net outflows from the stock market ($Flows_t$). In both levels and first differences regressions, estimated coefficients are significantly different from zero and point towards a positive (negative) relationship between the proportion of middle-aged (retired) and stock prices. Overall demographic variables show a strong explanatory power, particularly if used in first differences, with R^2 reaching more than 18%. Next, the analysis is extended to a multi-year forecast framework by estimating:

$$\sum_{i=1}^{K} RP_{t+i} = \beta_0 + \beta_1 \Delta Pop_{t,K}^{25-44} + \beta_2 \Delta Pop_{t,K}^{45-64} + \beta_3 \Delta Pop_{t,K}^{65+} + \beta_4 DY_{t,K} + \varepsilon_{t+K} \qquad (19)$$

where the dependent variable is the sum of next K-periods excess returns while explanatory variables include the divided yield and the projected percentage change in the proportions of population of aged 25-44, 45-64 and 65 or over between now and K-periods ahead.[7] Results are presented for three- and five-year horizons. In the former case demographic variables are individually not significant, while in the latter only β_2 is significant. In both cases however the demographic variables are jointly highly significant and their signs suggest an inverse (direct) relation between the proportion of middle-aged (retired) and stock returns. Goyal (2004) also explores the impact of demographics on macroeconomic indicators (MI), i.e.:

$$MI_{t+1} = \beta_0 + \beta_1 MI_t + \beta_2 RP_t + \beta_3 \Delta GNP_t + \beta_4 \Delta Pop_t^{25-44} + \beta_5 \Delta Pop_t^{45-64} + \beta_6 \Delta Pop_t^{65+} \qquad (20)$$

where MI is in turn the real GNP, the aggregate saving rate or the aggregate investment rate. Results highlight that the age structure of the population affects only marginally real GNP but can affect quite significantly both savings and investment rates.

In a recent work Brunetti and Torricelli (2007b) investigate the issue specifically for Italy, running time-series regression on annual data spanning over the period 1958-2004. The authors first follow Poterba (2001, 2004) and estimate regressions such as:

$$r_t = \alpha + \boldsymbol{\beta} \mathbf{D}_t + \varepsilon_t \qquad (21)$$

where r_t is the real return on either stocks, long-term government bonds or short-term government bonds (*Buoni Ordinari del Tesoro*, BOT), $\mathbf{D_t}$ is the vector of demographic variables, basically represented by the shares of different age-classes (20-40, 40-64, over 65) over total or adult population. Consistently with Poterba (2004), results for this

[7] As an example, $\Delta Pop_{t,K}^{25-44} = \left[\left(Pop_t^{25-44} / Pop_{t-K+1}^{25-44}\right)^{1/K} - 1\right]$.

specification are not always in line with expectations and appear not robust across the variants examined, leading the authors to the conclusion that demographic variables alone can not satisfactorily explain the dynamics of financial asset returns over the sample period considered. Then, observing that a purely demographic specification might be affected by omitted variables the authors estimate:

$$r_t = \alpha + \boldsymbol{\beta}\mathbf{D}_t + \boldsymbol{\gamma}\mathbf{F}_t + \varepsilon_t \tag{22}$$

where $\mathbf{F}_t$ represents a vector of financial variables, differently defined depending on the dependent variable. As Davis and Li (2003)[8], in the regression for equities the authors include dividend-yield, real long-term interest rate, stock prices volatility and GDP grow rate and output gap. As for long and short-term government bonds, the financial variables include the short-rate change, the term spread, inflation and once again GDP grow rate and output gap. In effect, from the extended specification a different picture emerges: the evidence is largely consistent across variants and suggests that demographic variables play a significant role in affecting financial returns. In particular, it emerges that the share of early (late) working-aged has a positive (negative) effect on the real returns on stocks. As for long-term government bonds, only early working-aged seem to significantly and negatively affect real yields, while late working-aged and retired seem not to play a significant role: probably they are not particularly active in this market due to the investment horizon, which is uninteresting to them. Based on the latter observation, the authors conclude that the impact of the projected ageing of Italian population might be more relevant for the stock rather than for the fixed-income market.

Erb et al. (1997) are among the first studies that *inter alia* employ panel data to empirically assess the relationship between real equity returns and average age. In fact, the dataset used spans over the period 1970-1995 and refers to 18 countries: Australia, Austria, Belgium, Canada, Denmark, France, Germany, Hong Kong, Italy, Japan, Netherlands, Norway, Singapore, Spain, Sweden, Switzerland, UK and US. First time-series and cross-section regressions are run. As for the former, the authors report a positive relationship between the proportion of middle-aged and equity returns. As for the latter, a positive relationship is detected between real equity returns and

[8] Although antecedent in a chronological order, the empirical study by Davis and Li (2003) is presented below as it is essentially based on panel regressions.

demographics across all countries. Then, data are pooled and, as in Bakshi and Chen (1994), the following forecast exercise is implemented:

$$r_{it+k} = \beta_0 + \beta_1 \Delta\overline{A}_{it} + \beta_2 LE_{it} + \beta_3 \Delta Pop_{it} + \varepsilon_{it} \tag{23}$$

in which the expected rates of return over the next K periods is regressed on three demographic measures: change in average age, current life expectancy and current population growth. Either considering one or five-year horizons, only $\Delta\overline{A}_{it}$ displays significant (and positive) coefficients. The explanatory power is however lower for one-year than for five-year regression, probably due to the high persistency of demographic variables with respect to rates of return. The authors find consistent results including in the sample 27 additional emerging countries[9], thereby proving further the forecast power of demographic variables on long-run expected returns.

Davis and Li (2003) use data spanning over the 1950-1999 period referred to 7 OECD countries: US, UK, Japan, Germany, France, Italy, and Spain. In order to empirically test the relationship between demographics and equities, the authors first estimate by means of GLS the following panel regression:

$$\begin{aligned} \Delta \ln\left(P^e\right)_{it} &= \beta_0 + \beta_1 Pop_{it}^{20-39} + \beta_2 Pop_{it}^{40-64} + \beta_3 \Delta GDP_{it}^{HP} + \\ &+ \beta_4 \Delta\left(GDP - GDP^{HP}\right)_{it} + \beta_5 LR_{it} + \beta_6 Vol\left(P^e\right)_{it} + \beta_7 DY_{it-1} + \varepsilon_{it} \end{aligned} \tag{24}$$

where the dependent variable is the log difference of real equity prices whilst explanatory variables include the shares of population aged 20-39 and 40-64 ($Pop_{it}^{20-39}, Pop_{it}^{40-64}$), the trend *GDP* growth rate (ΔGDP^{HP}), the output gap, defined as $\Delta\left(GDP - GDP^{HP}\right)$, the long-term real interest rate (*LR*), the average equity prices volatility ($Vol\left(P^e\right)$) and the lagged dividend yield (DY_{t-1}). Regression (24) is firstly estimated using data for all 7 countries and then using data for all countries but United States. In both cases, non-demographic variables are overall significant (except equity prices volatility) and correctly signed. Both demographic variables are strongly significant and positively signed, although the coefficient for Pop_{it}^{20-39} is lower in

[9] The 26 emerging economies are Argentina, Brazil, Chile, China, Colombia, Finland, Greece, Hungary, India, Indonesia, Ireland, Jordan, Malaysia, Mexico, New Zealand, Nigeria, Pakistan, The Philippines, Poland, Portugal, South Africa, South Korea, Sri Lanka, Thailand, Turkey, Venezuela and Zimbabwe.

magnitude with respect to Pop_{it}^{40-64}. Then Davis and Li (2003) aggregate cross-country data by using annual GDP as weights and estimate, by means of OLS, a time-series regression labelled as "international", which differs from (24) only for the absence of country-subscripts *i*. Here quite different results are obtained since most non-demographic variables are not significant and among demographic ones only Pop_{it}^{40-64} has a positive and significant coefficient. Yet, non-demographic and demographic variables together can explain overall up to 30-50% of the real equity prices variation, which is much more than what other studies report(e.g. Yoo (1994a) reports a maximum of 15%). Davis and Li (2003) also study the link between demographics and bond yields, i.e.:

$$\begin{aligned} LR_{it} = \beta_0 + \beta_1 Pop_{it}^{20-39} + \beta_2 Pop_{it}^{40-64} + \beta_3 \Delta SR_{it} + \beta_4 (LR - SR)_{it-1} + \beta_5 \Delta \ln(CPI)_{it} \\ + \beta_6 \Delta\Delta \ln(CPI)_{it} + \beta_7 \Delta GDP_{it}^{HP} + \beta_8 \Delta (GDP - GDP^{HP})_{it} + \varepsilon_{it} \end{aligned} \quad (25)$$

where the dependent variable is the bond yield and explanatory variables include, besides the ones defined above, the first difference of the short rate, the lag of the term structure differential and both lag and acceleration of inflation (i.e. the first and second difference of log Consumer Price Index). Once again regression (25) is estimated twice, first using data for all 7 countries and then excluding United States, obtaining in both cases similar results. Overall, both demographic and non-demographic variables are significant and results suggest a positive (negative) relation between young (middle-aged) generation size and bond yields. In the "international" regression $Pop_{i,t}^{40-64}$ is the only significant variable, but R^2 is nevertheless sizeable: around 80-90%. Both panel and international regressions are re-estimated including the share of over-65, leading to even more sticking results. Davis and Li (2003) thus conclude that demographic changes (especially those concerning the most financially active part of the population, i.e. aged 40-64) can have a significant impact on both stock prices and bond yields, even in presence of additional non-demographic explanatory variables.

Ang and Maddaloni (2005) examine the predictive power of demographic changes on future equity risk premium using use two distinct datasets. The first spans over the whole twentieth century and refers to France, Germany, Japan, US and UK.[10]

[10] Data for Japan span over the period 1920-2001 while those for other countries span over 1900-2001.

The second includes monthly data over a smaller sample period (1970-2000) for 15 developed countries, namely Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, UK and US. For the econometric analysis, the authors first study the predictability of the excess return k-periods ahead[11] (RP_{t+k}) over three different forecast horizons (k = 1, 2 and 5 years) estimating the following regression with GMM for each country separately:

$$RP_{t+k} = \beta_0 + \mathbf{\beta Z}_t + \varepsilon_{t+k} \quad (26)$$

where $\mathbf{Z}_t$ represents the set of explanatory variables including both demographic and control variables. As for the latter, the authors choose delayed consumption growth and term spread since both are recognized predictors of equity returns and have data available over quite long sample periods. As for the demographic measures, the authors employ the average age of adult population ($\overline{A}^{20+}$), the proportion of adults over 65 (Pop^{65+}) and the proportion of population in working age, i.e. aged between 20 and 40 (Pop^{20-40}), all used in first differences rather than in levels. Results are sensibly different depending on the country considered. For instance, for US only a weak positive relationship between demographics and excess returns is found. The same holds for UK, for which the only demographic measure robust to control variables across all forecast horizons is Pop^{65+}. On the other hand, in France and Germany all demographic variables are significant, although only at 10% level and over short time-horizons, displaying in addition negative signs in contrast to US and UK cases. Finally, in Japan all demographic variables show strongly significant and negative coefficients, at least at 1-year horizon. Next, the authors pool the data and estimate (26) across all 5 countries simultaneously. The results for the panel analysis confirm that Pop^{65+} is the only demographic variable that maintains significant predictive power across all forecast horizons, also when control variables are included. Finally, the authors extend the analyses to the 15 countries and re-estimate (26) using the monthly dataset. Also in this case results confirm the significant and negative correlation between Pop^{65+} and

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[11] Using annual data, the annualized *k*-period excess return is calculated as $RP_{t+k} = \frac{1}{k}\left(\sum_{i=1}^{k} RP_{t+i}\right)$ while for monthly observations it is defined as $RP_{t+k} = \frac{12}{k}\left(\sum_{i=1}^{k} RP_{t+i}\right)$ where RP_{t+i} are the log excess return in *t*+*i*.

excess returns across all forecast horizons. Ang and Maddaloni (2005) thus conclude that, despite some cross-countries differences[12], demographics play an important role in predicting excess returns.

Brooks (2006) constructs a long-run (1900-2005) panel dataset referred to a set of 16 developed countries. [13] The data are used to estimate by means of OLS:

$$y_{it} = \lambda_i + \beta_t + \gamma_1 Z_{1it} + \gamma_{21} Z_{2it} + \gamma_3 Z_{3it} + \varepsilon_{it}$$

with (27)

$$Z_{Nit} = \sum_{j=1}^{J} j^N p_{jit} - \frac{1}{J} \sum_{j=1}^{J} j^N \text{ , } N = 1,2,3$$

where y_{it} is either the price or the total return on stocks, stock indices, bonds and T-Bills, while the explanatory variables include two dummies, λ_i for the country and β_t for the year, and indirectly $p_{1it}, p_{2it}, ..., p_{Jit}$, i.e. the shares over the entire population of people in the *J* age group. It is worth noticing that the econometric specification proposed by Brooks (2006) is slightly different from the ones commonly used in the relevant empirical literature. First, in order to control for the possible impact of events such as the Great Depression, World War II and the oil shocks, the author uses the β_t dummy while other works, such as Davis and Li (2003), control by including into the models some non-demographic variables. Second, as in Yoo (1994a), the author allows the entire age distribution to enter the regression, thereby avoiding an arbitrary partition of the population. Third, the demographic variables are not explicitly included into the model, so that the coefficients $\gamma_1, \gamma_2, \gamma_3$ are not directly interpretable: yet, the implicit age-coefficients, capturing the sensitivity of asset price and returns to age distribution, can easily be recovered. The results are presented for both financial asset prices and returns. Indeed different pictures arise: with asset prices a significant effect of age is reported as the older the population, the lower the price of stock relative to T-Bill. On the other hand, using real financial asset returns only little evidence of a link between demographics and financial markets is found and only with regards to fixed-income market, consistently with Poterba (2001, 2004) and opposite to Davis and Li (2003) and

[12] In particular, the authors observe more significant and higher coefficients for countries with more generous social security systems and less developed financial markets.

[13] The countries analysed are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland, UK and US.

Brunetti and Torricelli (2007b). Furthermore, when (27) is estimated allowing the coefficients $\gamma_1, \gamma_2, \gamma_3$ to vary across countries, the results point towards a substantial heterogeneity across countries. In particular, Brooks (2006) observes that "*English-speaking economies […] do not conform well the life-cycle hypothesis*", thereby confirming the little evidence of decumulation during retirement already reported by other studies (e.g. Poterba (2001) and GAO, 2006). By contrast, countries such as Italy, Finland, Sweden, Norway and Japan exhibit the more familiar life-cycle pattern, which the author brings back to the limited household participation to the equity markets that characterizes these countries. Based on his results, Brooks (2006) concludes that "*it is hard to make a case for the asset-price meltdown scenario*", at least with regards to those economies with strong equity-market participation.

3.3 Simulation-based studies

Although only recently, the empirical literature is increasingly making use of model simulations to assess the possible reaction of future asset prices and returns, together with other macroeconomic variables, to projected demographic scenarios. Most of these works base their simulations on OLG models, although an alternative approach, based on a dynamic asset pricing model, has recently been proposed by Kedar-Levy (2006). Results from this stream of literature are the most disparate; hence, in what follows we present contributions according to their main results, starting from those basically supporting the AMH and concluding with those reaching less clear-cut conclusions.

The works by Brooks (2000, 2002) are among the most representative simulation-based studies aimed to assess the implications of ageing on financial market. Both works are based on a closed-economy OLG model with rational and forward-looking agents: yet, they substantially differ for the demographic changes simulation. Yet, in both cases the results are comparable and point towards relevant repercussions of demographic dynamics on financial markets. Brooks (2000) explores the effects that ageing might have on the rates of return of both safe and risky assets. He assumes rational and forward-looking agents with no bequest and who, consistently with life-cycle theory, increasingly prefer bonds to stocks as they age. After having numerically solved the model, Brooks (2000) studies the effects of two demographic shocks: a baby-boom between *t* and *t+2*, simulated by increasing population growth rate from zero to 2%, and a subsequent baby-bust between *t+2* and *t+4*, simulated with a drop in the rate of population growth to -2%. The results point towards significant impact of these demographic changes. In particular, during the baby-boom aggregate savings decrease, putting downward pressure on asset prices and correspondingly increasing both stocks and bonds returns. By contrast, the opposite occurs during the baby-bust. Accordingly, the equity premium decreases during baby-boom and increases during baby-bust. Hence, even accounting for rationality and forward-looking behaviour, demographic changes may affect financial markets, although the effect might be modest in size. The same experiment is then repeated by the author in a subsequent work, i.e. Brooks (2002), in which however real demographic data are used, referring to US and spanning over the 1870-2020 period. In this case the demographic changes simulated are: (i) a pre-war baby bust in the 1940; (ii) a post-war baby boom in 1960; and (iii) a post-war baby bust in 1980. In response to each of these demographic changes, the OLG simulations highlight different pattern for savings rates and rates of return. In particular, the first baby bust leads to an increase in savings and thus in financial assets demand, thereby driving down both risk-free and risky rates of returns. On the other hand, the 1960 baby-boom increases the need to borrow money to finance consumption, thereby leading to progressively higher risk-free returns. Risky returns are also projected to increase, but less than the risk-free, so that the baby boom translates into a lower equity risk premium. In sum, over the whole simulation period the author estimates the risk premium to substantially rise, to about triple its steady-state level in 2000, but then assuming no other demographic shocks in the future, it is expected to fall again to half its current level by the time the baby boomers retire, i.e. around 2020.

Geanakoplos et al. (2004) develop two versions of a closed-economy OLG model: one "stochastic", including business cycle shocks, and one "deterministic", in which the size of the generations, dividends and wages are set in accordance with historical data for the US. Agents are assumed to behave according to the life-cycle hypothesis and to be either myopic or forward-looking, i.e. able to discount future demographic evolution. In the myopic-agent case, the model predicts that stock prices vary proportionally with MY, i.e. the ratio of middle-aged to young people, defined as

N_{MA}/N_Y where N_{MA} is the number of middle-aged and N_Y that of young.[14] In the forward-looking agent case, the middle-age generation saves even more, boosting the investments and the consequent upward pressure on stock prices. Accordingly, prices reach the maximum when the size of middle-aged generation reaches the maximum and vice versa. By contrast, changes in rates of returns are still consistent with demographic phases, but strongly out of phase. Geanakoplos et al. (2004) also use linear regressions to further investigate this issue. More precisely, they first regress the price-earning ratios of the S&P500 firms (P/E) on MY and find positive and highly significant coefficients coupled with R^2 ranging from 48% to around 78%. Next, they run the following regression:

$$y_t = \beta_0 + \beta_1 \Delta\left(\frac{N_{MA}}{N_Y}\right)_t + \varepsilon_t \tag{28}$$

where y_t is either the S&P500 rate of return or the real short-term interest rate. While the link with the short-term interest rate seems weak, the MY can explain up to 14% of the variability of stock market return. Some international evidence is also provided, using data for Germany, France, Japan and UK spanning over the period 1950-2001, by estimating:

$$P_t = \beta_0 + \beta_1 Demo_t + \varepsilon_t \tag{29}$$

where P_t is the real stock price index and $Demo_t$ is either MY or the size of the 35-59 cohort of the country under analysis. They find mixed results: no relationship at all in UK, weak relationship in Germany, relatively significant relationship in France and quite strong relationship in Japan, which also in this study results among the countries in which the demographic changes more soundly affect financial markets.

Recently, Kedar-Levy (2006) has proposed an alternative theoretical framework which demonstrates that ageing might have a positive effect on equilibrium stock prices, reconciling the empirical evidence reported in several works, such as Poterba (2001, 2004) and Ang and Maddaloni (2005) with theoretical indications. Traditional OLG models draw their conclusion of declining stock prices based on the retirees' dis-savings. Kedar-Levy (2006) on the other hand proposes a dynamic-asset-pricing-model

[14] These results are also robust to the inclusion of bequests, PAYG social security payments/transfers and children consumption providing.

in which investors optimize their portfolios anticipating that an increase in the proportion of elderly will reduce their lifetime subsistence level (named “floor”). As a reaction, they increase their optimal exposure to the risky asset thereby exerting an upward pressure on the relative prices. Simulations on this model are performed using US data spanning over the period 1950-2050. Results suggest only modest effect until 2015 (minus 0.06% over yearly returns), since for the next decade the bulk of baby boomers will still be part of the working-force. By contrast, starting from 2016 the first boomers will retire, the working-force will shrink and the investors’ floor will lower, forcing them to increase their risk-exposure: as a result, risky asset prices are estimated to increase by around 0.22% every year.

Results reported in the contributions reviewed so far are contrasted in the following simulation-based studies, which provide evidence of only modest, if any, effect of demographic shifts on financial asset prices and/or returns.

For instance, Young (2002) *inter alia* simulates the ageing implications on UK asset prices by means of a closed-economy OLG model[15] using data spanning over the period 2000-2050. The author simulates three different demographic shocks: (i) a baby boom; (ii) an increase in longevity; and (iii) a decline in fertility. In effect, while consequences on living standards are likely to be substantial, Young (2002) finds only modest effects on interest rates and asset prices.

As Börsch-Supan (2004) puts it “*Börsch-Supan et al. (2003) embed a calibrated dynamic portfolio choice model into an OLG model*” and find that “*The risk-free rate is predicted to decrease relatively sharply during the next 25 years […] much strongly than the decrease in the rate of return of stocks. After 2027, the rate for safe assets increases again, while the rate for stocks remains essentially stable*. Hence, although the equity premium is likely to initially increase (by about 70 basis points up to 2025) the effect will only be temporary.

Oliveira Martins et al. (2005) study the long-run effects of population ageing on “factor markets”, i.e. capital and labour market, by performing simulations over the

[15] Actually, two different OLG models are implemented. In the first households are assumed to choose the optimal level of consumption and savings according to the life-cycle hypothesis. The second assumes instead that consumption (and savings) in each life-period is determined as a fraction of current resources. More specifically, all labour income is consumed in the first life-period, 90% in the second, 80% in the third, 70% in the fourth and all the remaining resources in the fifth and last period of life. However, simulations on both models overall lead to comparable results.

period 2000-2050 on an OLG model calibrated to fit the characteristics of US (slow ageing), France (intermediate ageing), Japan and Germany (fast ageing). Three different pension-systems scenarios are assumed: (i) increasing contribution rate; (ii) increasing retirement age; and (iii) decreasing replacement rate. The results highlight only a modest influence of ageing on capital markets, showing that real returns are expected to decline only under scenario (iii) and never more than 1 percentage point. Based on this evidence, the author concludes that there is "*little support to the asset meltdown hypothesis*".

Saarenheimo (2005) performs simulations on an OLG model in which the five major world areas, namely USA, EU15, Japan, China and India, act as single homogeneous countries. Among other things, the author finds a quite limited risk of a financial market meltdown: according to the author the effect of the reduced number of savers due to population ageing is likely to be more than offset by the effect of a continuously increasing life expectancy which will keep basically unchanged the aggregate demand for financial assets.

4. Conclusions

Among the manifold financial implications of population ageing, those concerning the household portfolio allocations and financial asset returns are increasingly receiving attention from both theoretical and empirical literature. The latter in particular is quite disparate not only for implications investigated, but also for methodology taken, country analysed and results obtained. With the aim to give an overall idea about the main findings reported so far, this paper provides an overview of the most recent empirical studies assessing the impact of ageing on household portfolios and on financial asset prices and returns. Most of the extant literature on these issues focuses on the US case, also due to longer and better data availability. Other countries, including those experiencing quite urgent ageing processes (e.g. Japan, Italy and Eastern Europe countries), are considered only rarely and at a comparative level, with very few exceptions (e.g. Guiso and Jappelli (2001) and Brunetti and Torricelli (2007a) for Italy and Ganelli (2006) for Czech Republic).

As for the relationship between age and household financial portfolios, most of the works are not at variant with the standard life-cycle hypothesis. Regardless of the methodology taken, the general evidence is of young household generally allocating a bigger share of their portfolios in riskier activities, while older ones choosing safer assets in the light of higher risk-aversion. In spite of this common evidence, the conclusions reached in terms of effective asset meltdown may be different depending on the actual financial dis-saving by retirees. For instance, Bellante and Green (2004), despite finding age to be a significant determinant of portfolio allocation, conclude that, at least for the US market, a real "asset meltdown" is implausible since evidence on the US retirees point towards only weak financial dis-saving at retirement.

The empirical results on the link between population age-structure and financial asset returns are instead less uniform. On one hand, explorative and econometric studies report significant correlations and generally agree that a wider share of young exerts an upward pressure on risky asset prices and returns, while the preference of elderly for liquid and safer portfolios overall increase the demand for fixed-income assets, thereby increasing their prices and reducing their returns. On the other hand, between the two possible conclusions of significant rather than only modest and/or temporary impact of ageing on financial asset returns simulation-based studies are equally divided. Clearly their computational complexity and the need of initial model calibration may play a role in determining numerical results, but model assumptions also matter. Besides the behaviour of single investors (e.g. rational rather than non-rational, myopic rather than forward-looking), assumptions on the whole economy also make the difference: e.g. models with open rather than closed economies point towards less dramatic scenarios, since international capital flows allow the ageing processes, occurring at different paces across countries, to compensate through (integrated) financial markets. Furthermore, most of the simulation-based works focus on US or UK, which not only experience ageing processes certainly less urgent than Japan or Italy, but also have less generous public pension systems and generally more efficient and developed financial markets, which are in turn crucial factors to consider when assessing the potential consequences of population ageing on household portfolios and financial asset returns.

Based on the latter observations, a possible way to effectively single out the consequences of population ageing on financial asset markets could be in performing comparative analyses on countries with comparable pension systems and financial market development but different demographic dynamics.

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